Scand J Work Environ Health 12 (1986) 269—271

Vibration-induced effects caused by impact wrenches used in truck assembly

by Lars Jorulf, MD[1]

JORULF L. Vibration-induced effects caused by impact wrenches used in truck assembly. *Scand J Work Environ Health* 12 (1986) 269—271. The objective of the study was to evaluate the risk of developing vibration-induced white finger (VWF) and numbness during truck assembly with impact wrenches, and the method used was a cross-sectional study made with questionnaires. Of the 904 workers asked about their use of the tool, 262 were identified as "solely exposed" to impact wrenches, the mean exposure time being 6.7 years. The acceleration range was 3.9—18.1 m/s^2. When the exposure dose was estimated by exposure years, a dose-response relationship existed up to the exposure class 7—9 years. In this exposure class, 23 % were affected by VWF and 33 % by numbness. Although the results indicate moderate vibration-induced effects for most of the impact wrenches in use during truck assembly, the effects can be considerable for some of the tools. For the numbness symptom, confounding factors and some other aspects may make the result more uncertain.

Key terms: numbness, questionnaire, weighted acceleration, white fingers.

In Sweden, it has been estimated that impact wrenches make up one of the two most frequently used types of pneumatic tools (25 000 wrenches and drills). They are generally used together with other vibrating tools. In the assembly of trucks, the use of the wrench is dominant, and this fact has provided the opportunity of evaluating its effect without the influence of other vibrating tools.

Of the various symptoms constituting the vibration syndrome, this study only deals with symptoms of vibration-induced white finger (VWF) and the presence of numbness in the hand-arm.

The objective of the study was to evaluate the risk of developing VWF and numbness during the use of impact wrenches in the assembly of trucks. It was hoped that the results would also give a better basis for the treatment of workers with symptoms (changing jobs, reporting on industrial illnesses) and a better basis for an initiation of work on and the reduction of exposure to vibration.

The acceleration of the tools most often used has been measured on a test bench in cooperation with the National Board of Occupational Safety and Health, Stockholm (table 1). The acceleration range was 3.9—18.1 m/s^2 during the wrenching of 12- to 20-mm nuts. These data were also published by the National Board of Occupational Safety and Health in 1985 (1). The tools are used in short operations (5—10 s of vibration time) repeatedly during the day. The total vibrating time per day was usually 10—15 min, corresponding to 10—20 fastenings/h. At the time of the study in December 1981-March 1982, older tools were the most commonly used, and their acceleration has therefore had more influence on vibration-induced effects than tools of more recent design.

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Subjects and methods

The study was a cross-sectional one made with a self-administered questionnaire. If requested, help in clarifying the questions was given by nurses and worker safety delegates. The study group was chosen from the production workshops, where the impact wrenches were the most uniformly used.

Table 1. Vibration amplitude of the most commonly used tools measured on a test girder. Mean and standard deviation of 10 tests per tool (1).

Impact wrench	Year taken into use	Nut size (mm)	Time (s/nut)		Acceleration (m/s^2 root-mean-square)	
			Mean	SD	Mean	SD
LMS 11	1960	12	6.2	1.2	5.2	0.7
IR 5040[a]	1968	14	8.7	4.6	18.1	6.6
CP 9540[b]	1970	14	6.7	1.7	3.3	0.6
CP 9540[c]	1970	14	14.7	1.9	7.6	1.4
IR 2910	1972	20	5.2	1.0	7.0	0.7
IR 231	1978	14	7.2	2.5	6.1	1.0
LMS 26	1979	14	7.9	1.6	4.0	0.9
LMS 36[d]	1979	16	6.4	0.7	4.3	2.0
LMS 36[d]	1979	16	6.2	0.9	3.9	1.4
LMS 36[d]	1979	16	5.8	0.6	5.9	1.7
LT 26[d]	1981	14	10.0	3.1	3.9	1.0
LTS 26[d]	1981	14	7.3	3.0	4.5	1.0

[a] Tool with torque limit.
[b] Slack wrenching.
[c] Wrenching with prolonged time.
[d] Different machines.

All 904 workers (practically 100 % male) were asked about their use of the tools during their employment at the Volvo Truck Corporation. The response rate was 94 %, and a total of 504 persons had used one or more of the tools. In order to identify the largest possible group to which the impact wrenches had been the most important source of vibration, the following exclusions were made: (i) those exposed to other vibrating tools at the Volvo Truck Corporation, (ii) those with exposure in former employment, depending on the period of time since exposure, the time when symptoms occurred, or until the outbreak of them (ie, if a period longer than the exposure time in the former employment had elapsed, the later use of vibrating tools at Volvo was considered to be the main source of vibration and the worker was accepted to the study, otherwise not), and (iii) those with leisure-time exposure of more than 1 h week. After these exclusions, there remained 262 persons who constituted a "solely exposed" group, which had a mean exposure time of 6.7 (range 0.2—28.3) years.

The positive VWF symptom was obtained by an affirmative answer to the question if the following had been experienced: "White fingers is an attack of spasm in the blood vessels occurring in one or more fingers in connection with cooling. The finger becomes white and insensitive, but the circulation returns after a while — sooner if the finger is rubbed or warmed." A positive numbness symptom was recorded if an affirmative answer was given to the question of whether numbness had been experienced in the hand-arm without, at the same time, symptoms of VWF.

As it was not possible to include a reference group in the study for practical reasons (insufficient resources), the possibility of a dose-response relationship was examined instead. In the statistics, the following tests were used: the Pitman test (a nonparametric test for relation between two variables) and the Fischer test (a special test of the previous one, where X or Y can have only two values). Probability of less than 0.05 was consistently used as the level of significance.

Results

The white finger "positives" were three years older and the numbness "positives" were 1.4 years older than the "negatives," but these differences were not significant (table 2). In a comparison of the confounding factors asked about, there were significantly more smokers and hand-arm injuries in the numbness "positive" group. In the VWF group, approximately the same difference existed although it was not significant (table 2).

A total of 31 workers (12 %) answered the question about white fingers affirmatively. The question about numbness was answered affirmatively by 56 workers (21 %). Out of these, 18 workers answered both questions affirmatively.

Table 2. Percentage distribution of the confounding factors.[a]

Confounding factor	Subjects experiencing white fingers[a] (N = 31) (%)	Subjects not experiencing white fingers[a] (N = 231) (%)	Subjects experiencing numbness (N = 56) (%)	Subjects not experiencing numbness[a] (N = 206) (%)
Smoking	54.8	42.9	55.4*	41.3*
Diabetes	3.3	0.4	1.9	0.5
Hand-arm injuries	25.8	12.2	37.5*	7.3*
Hypertension	6.4	5.3	1.9	6.4
Next-of-kin with symptoms	3.6	2.2	0.0	3.0
Leisure exposure more than 1 h/week	0.0	0.0	0.0	0.0

[a] Mean age (years): subjects experiencing white fingers 37.7, subjects not experiencing white fingers 34.7, subjects experiencing numbness 36.1, subjects not experiencing numbness 34.7.
* Differences significant.

Table 3. The proportion of symptoms in different exposure classes.

	Length of exposure									
	<1 years (N = 24)		1—3 years (N = 91)		4—6 years (N = 42)		7—9 years (N = 40)		≥10 years (N = 65)	
	N	%	N	%	N	%	N	%	N	%
Subjects experiencing white fingers	1	4*	7	8*	8	19*	9	23*	6	9
Subjects experiencing numbness	1	4*	17	19*	10	24*	13	33*	15	23

[a] Mean age (years): <1-year group 24, 1—3-year group 31, 4—6-year group 35, 7—9-year group 37, and ≥10-year group 43.
* Significant increasing tendency up to exposure class 7—9 years.

When exposure dose was estimated by exposure years, a dose-response relationship existed up to exposure class 7—9 years. In this class, 23 % were affected by VWF, and 33 % by numbness (table 3). Both symptoms were 30 % more frequent on the right-hand side of the body. For most of those affected, the symptoms were mild in character. For the symptom VWF and for the symptom numbness 13 and 27 %, respectively, stated that they had difficulties when working, 16 and 11 %, respectively, had sometimes been on the sick list, and 6 and 5 %, respectively, had been forced to change jobs due to these symptoms.

Discussion

As shown by Wasserman et al (2), good consistency can be shown between VWF symptoms on questionnaires and clinical diagnosis. For the numbness symptom this relation is unknown, but, in view of the more diffuse character of this symptom, the consistency may be poor.

The larger proportion of hand-arm injuries in the symptom groups may, to some extent, be casual, especially for the numbness symptom. A more probable explanation may however be that more intense work with impact wrenches implies a risk of more accidents and more symptoms.

As the distributions of age and background factors for VWF were not significantly different between the groups with and without symptoms, there are relatively strong reasons to state that causes other than vibration have had little influence on the dose-response relationship. Furthermore, one other major cause of white fingers, according to Raynaud, generally has its debut at younger ages and therefore is presumed to give little contribution with age in the actual age groups (table 3). The dose-response relationship therefore indicates, relatively strongly, a casual relationship.

For the numbness symptom on the other hand, and subject to the aforementioned reservations, the significant differences of background factors, and the more unknown clinical counterparts to the symptom, the indication of a causal relationship is presumed to be weaker.

As there was no great change of exposure during the nine-year period prior to the study, the results reflect the actual risk at that time.

The reduced proportion of affected subjects in the longest exposure class (≥ 10 years) is difficult to explain totally. To some extent it may be due to the so-called healthy worker effect — the symptoms have forced workers to leave the production workshops. There is also an overall greater chance of structural changes acting in a nonrandom way (job changes, retirement) in this very wide exposure class (up to 28.3 years).

The relatively small difference between frequencies of symptoms of the right and left hand may be explained by the fact that the left hand is often used to hold the screw, bolt, or nut during wrenching, and it is thus also exposed to vibration.

The risk magnitude as indicated in this study is a mean of the effects of several different wrenching tools with different accelerations. Therefore, for some tools, especially the IR 5040, the risk might be even greater.

Acknowledgments

Safety engineer A Wikström measured the accelerations in cooperation with the National Board of Occupational Safety and Health. Ms E Winkvist and Mr M Härnqvist, Volvo Data Corporation, compiled the statistics.

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